b) ***Development of externally driven 11.424 GHz dielectric-loaded structures and high-power tests at NRL:*** This is an exciting near term application of wakefield derived technology using an external rf power source to drive a dielectric structure. A series of high power tests were conducted at NRL during this period, and a number of significant physics results were obtained.

Based on our recent switch to a modular dielectric structure, the production cycle of the structure has been greatly reduced. During this period, high-power tests have been carried out on three Dielectric-Loaded Accelerating (DLA) structures using two dielectric materials: Alumina (dielectric constant of 9.4) and $Mg_xCa_{1-x}TiO_3$ (dielectric constant of 20). Progress has been made and new physical phenomena observed. Problems arising in each of these experiments have been investigated, understood and are now being solved. These high-quality experiments have resulted in publications in both Physical Review Letters and the IEEE Trans. on Plasma Science.

In order to suppress multipactoring in alumina based DLA structures (discovered in the previous experiment) we coated the inner surface of alumina tube with 20nm layer of TiN. Although we did not observe the complete elimination of multipactoring effects during this test, multipactoring onset did not appear until the accelerating gradient was 60% higher than in the uncoated structure. More importantly, the multipactoring related RF absorption saturated in the interval between 1 – 5 MW of incident power, or gradient from 4 – 8 MV/m, as opposed to the monotonic increase of absorbed power in the uncoated structure.

Two experiments using the $Mg_xCa_{1-x}TiO_3$ (MCT) based DLA structures were performed during this period. We discovered that dielectric breakdown occurs in the joint between the tapered matching section and the straight accelerating section due to small gaps in this joint due to imperfections of the dielectrics and machining errors. Simulations revealed that a gap in this joint produces a strong local field enhancement (20 times greater than the field in the dielectric). The breakdown occurred in the joint at ~ 5.7 MV/m of axial field but with more than 100 MV/m field at the input dielectric joint. The breakdown threshold indirectly shows that MCT-based DLA structures may support electrical fields of 100 MV/m.

To further test the dielectric joint breakdown, we recently filled the gap at the joint with a high-Q epoxy and performed a high-power test. According to the manufacturer, the epoxy has a dielectric constant of 5.2 and a dielectric strength of 23.6 MV/m. Based on this dielectric constant, we expect that the local field enhancement factor should be reduced from 20 to 3.8 thus allowing higher gradient operation. As expected, the accelerating field realized during this high-power test increased to 7.5 MV/m (from 5.7 MV/m) before the typical breakdown signatures were observed. This accelerating electric field implies an electric field of ~28 MV/m at the upstream dielectric joint. This field is greater than the dielectric strength of the epoxy which is why breakdown occurred. The conclusion we draw from the high-power RF tests of the MCT based DLA structure is that all the gaps must be avoided. Therefore, we have started to develop a new structure design to test a gapless dielectric loaded accelerating structure in the near future.

In collaboration with S. Gold of NRL, and working with accelerator laboratory at Tsinghua University, China, we will install a new X-band injector at the NRL, as part of dedicated X-band accelerator test facility. Construction of the injector has been completed and it is to be delivered to ANL in March 05.